

MEMORANDUM

To: Amy Hambrick, U.S. EPA, Sector Policies and Programs Division/Natural Resources and Commerce Group

From: Eastern Research Group, Inc.

Date: January 2011

Subject: Revised Cost and Emission Reduction of the MACT Floor Level of Control

1.0 BACKGROUND

The U.S. Environmental Protection Agency (EPA), under section 129 of the Clean Air Act (CAA), is required to regulate emissions of nine pollutants and opacity from existing sewage sludge incineration (SSI) units. The nine pollutants are: hydrogen chloride (HCl), carbon monoxide (CO), lead (Pb), cadmium (Cd), mercury (Hg), particulate matter (PM), total mass basis dioxins/furans (TMB PCDD/PCDF) and toxic equivalency basis dioxin/furans (TEQ PCDD/PCDF), nitrogen oxides (NO_x), and sulfur dioxide (SO₂). The CAA requires EPA to determine the maximum achievable control technology for each subcategory of sources. To do so, EPA must first determine the minimum stringency “floor” requirements. A previous memorandum documents the MACT floor analysis for SSI units.¹ The purpose of this memorandum is to present the nationwide costs and nationwide emission reductions estimated for existing sources complying with the MACT floor level of control. This memorandum also discusses the costs and emission implications of an alternative sewage sludge disposal technique, landfilling. This memo is organized as follows:

- 2.0 Selecting Controls Needed for Each Unit to Meet MACT Floor Limits
- 3.0 Compliance Costs
 - 3.1 Emission Control Costs
 - 3.2 Stack Testing, Monitoring, and Recordkeeping Costs
 - 3.3 Alternative Disposal Costs
- 4.0 Emission Reductions
 - 4.1 Emissions Reductions based on ‘Actual’ Baseline Estimates
 - 4.2 Emissions Reductions based on ‘Potential’ Baseline Estimates
- 5.0 References
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2.0 SELECTING CONTROLS NEEDED FOR EACH UNIT TO MEET MACT FLOOR LIMITS

A significant portion of the total cost for industry compliance comes from the cost of installing new pollution control devices or improving existing pollution control devices for units not currently meeting the proposed limits. In order to determine the control costs, it was necessary to evaluate, for each SSI unit, how much improvement for each pollutant would be needed to meet the proposed emissions limits.

The average pollutant concentration values used to calculate baseline annual emissions² for each unit were compared with the proposed emissions limits, and percentages were calculated to quantify the amount of improvement needed for the unit to meet the proposed limits. Tables 1a and 1b contain the baseline pollutant concentration values used for each unit in each subcategory and the percentage improvement required to meet the proposed emissions limits for each unit for each pollutant. The existing SSI units are subcategorized into two main groups: multiple hearth (MH) units and fluidized bed (FB) units. The pollutant- and subcategory-specific limits are shown in each header row of these tables.

Control methods and cost algorithms utilized in a recent rulemaking for another waste combustion source category, Hospital, Medical and Infectious Waste Incinerators (HMIWI) were updated and utilized generally for the SSI source category, since most of these algorithms can be tailored to the combustion units found in the SSI source category with slight modifications. Additional algorithms were obtained from the OAQPS Control Cost Manual. Based on these required improvements, pollutant-specific control methods were chosen as follows for units requiring more than 10 percent improvement to meet the proposed limits. It was assumed that units within 10 percent of the limit would be able to meet the limit by making minor adjustments to the unit and/or controls already in place.

Metals (cadmium and lead) and PM: Adding venturi scrubbers where not already installed. If a limit is not met and a venturi scrubber is already installed, a wet electrostatic precipitator (WESP) is prescribed.

Mercury and dioxins/furans (PCDD/PCDF): No further improvement was needed for units to meet the MACT floor limit. However, beyond-the-floor options required the addition of activated carbon injection (ACI) (in combination with a fabric filter) and adjusting the carbon addition rate to meet the amount of reduction required. The costs and emission reductions associated with the beyond-the-floor options are discussed in the memorandum “Revised Analysis of Beyond the Maximum Achievable Control Technology (MACT) Floor Controls for Existing SSI Units.”³

Hydrogen chloride (HCl): Adding packed bed scrubbers.

Carbon monoxide (CO): No further improvement was needed for units to meet the MACT floor limit. However, beyond-the-floor options required the use of afterburner retrofits for units not already having similar control. The costs and emission reductions associated with the proposed CO limit are discussed in the memorandum “Revised Analysis of Beyond the Maximum Achievable Control Technology (MACT) Floor Controls for Existing SSI Units.”³

Nitrogen oxides (NO_x): Adding selective non-catalytic reduction (SNCR) systems.

Sulfur dioxide (SO₂): Adding packed bed scrubbers.

Further descriptions of these controls and their associated costs are listed below in Section 3.0.

3.0 COMPLIANCE COSTS

This section presents the nationwide costs estimated for existing SSI for (A) the emission controls used to comply with the proposed limits; (B) the monitoring, testing, recordkeeping, and reporting activities used to demonstrate compliance; and (C) the alternatives to compliance.

Total capital cost for all existing SSI units to meet the proposed MACT floor emission limits is estimated at approximately \$55.0 million. Total annual cost for controls for all units is about \$17.8 million/yr. Tables 2a and 2b present detailed costs for emission controls, stack testing, monitoring, and reporting and recordkeeping for each unit within each subcategory, as well as costs for alternatives to compliance where applicable. Based on these estimates, Table 3 summarizes two cost scenarios, the first in which all units comply with the proposed emission limits, and the second in which large entities comply and small entities shut down their SSIs and divert their dewatered sludge to a landfill. Large entities are defined as those for which the owner population is greater than or equal to 50,000 people, and small entities are those for which the owner population is less than 50,000. Facility owner populations are provided in the SSI inventory database memorandum⁴ and revisions in the database revisions memorandum.⁵

3.1 Emission Control Costs

Emission control technologies and other control measures that EPA identified that may be applicable to comply with the MACT floor options for existing SSI units include packed bed scrubbers, venturi scrubbers, wet electrostatic precipitators (WESPs), and selective non-catalytic reduction (SNCR). This section presents the costs that were estimated for each of these control measures.

The retrofit factors for the capital costs ranged from 1.2 to 1.4 for considered controls.⁶ Downtime costs for the retrofits were assumed to be negligible. Most SSI are expected to have adequate space to install an emission control system without shutting down the incinerator for an extended period. It was also expected that connecting the ductwork could be performed during a scheduled downtime for maintenance or during periods of inactivity, thereby minimizing expected downtime.⁷

The capital and annual costs for the emission controls were estimated in units of dollars (\$) and \$/flow. The \$/flow costs were calculated by dividing the capital/annual control cost estimate for each unit by the average gas flow rate assigned to that unit.

Total capital cost for controls for all subcategories is estimated at approximately \$43 million, and total annual cost for controls for all subcategories is about \$11.0 million/yr. Costs are on a 2008 basis, and annualized costs assumed an interest rate of 7 percent. Tables 4a-4e present a summary of the parameters and equations used in the cost algorithms for each emission control and alternative to compliance where applicable. Tables 5a and 5b lists of the unit-specific inputs for each subcategory used in the algorithms (e.g., incinerator charge rate, stack gas flow rate, incinerator operating hours, and concentrations).

a. Adding a venturi scrubber.

The cost algorithm for installing a venturi scrubber is based on the OAQPS Control Cost Manual.⁶ The venturi scrubber algorithm output is shown in Table 4a, and default values used in the algorithm are presented in Table 4b. The VS capital costs range from approximately \$71,000 to \$141,000, and annual costs range from approximately \$90,000/yr to \$169,000/yr.

b. Adding a packed bed scrubber.

The cost algorithm for installing a packed-bed wet scrubber is presented in Table 4c and is based on algorithms in the *Model Plant Description and Control Cost Report* for HMIWI.⁸

The packed-bed wet scrubber capital costs range from approximately \$375,000 to \$4.7 million, and annual costs range from approximately \$87,000/yr to \$1.0 million/yr. Sources for specific cost data are noted below Table 4c.

c. Adding a selective non-catalytic reduction (SNCR) system.

In an SNCR system, a nitrogen-based reducing agent, or reagent, such as ammonia or urea, is injected into the post-combustion flue gas through 3 nozzles mounted on the wall of the combustion unit. The cost algorithm for installing an SNCR system is presented in Table 4d and is based on algorithms in the *OAQPS Control Cost Manual*.⁶ An SNCR system was costed for only one facility (two units), and for each unit the capital cost was approximately \$1.2 million and the annual cost approximately \$133,000/yr. Sources for specific cost data are noted below Table 4d.

d. Adding a wet electrostatic precipitator (WESP).

The cost algorithm for installing a WESP is presented in Table 4e and is based on algorithms in the *OAQPS Control Cost Manual*.⁶ The WESP capital costs range from approximately \$2.3 million to \$2.8 million, and annual costs range from approximately \$406,000/yr to \$499,000/yr. Sources for specific cost data are noted in the source/notes column of Table 4e.

3.2 Stack Testing, Monitoring, and Recordkeeping Costs

Monitoring Costs. Initial and continuous compliance provisions for SSI units were selected to be as consistent as possible with proposed commercial and industrial solid waste incinerator (CISWI) and current HMIWI provisions. This section presents the costs that were estimated for each of these requirements.

The total capital cost for stack testing, monitoring, and recordkeeping and reporting for all subcategories is estimated at approximately \$12.0 million, and the total annual cost is about \$6.8 million per year. Cost estimates were based on algorithms recently utilized in the HMIWI regulatory development. Costs were updated to a 2008 basis, and annualized costs assumed an interest rate of 7 percent. Tables 6a-6f present a summary of the parameters and equations used in the cost algorithms for each monitoring component, where applicable.

Inspections. Consistent with HMIWI regulations, it was assumed that annual control device inspections will be required for any units having control devices in place or requiring further controls to meet the proposed emission limits. In this context, control devices include fabric filters, afterburners, wet scrubbers, or ACI systems. The cost was estimated at a flat rate of \$1000 per year. See Table 6a for further details and sources.

Parameter monitors. Monitoring of operating parameters can be used to indicate whether air pollution control equipment and practices are functioning properly to minimize air pollution. Based on the existing CISWI regulations and HMIWI regulations, it was assumed that parameter monitoring will be mandatory for all units required to add fabric filters, wet scrubbers, or ACI systems. Costs for each monitoring system were estimated as follows:

- For a wet scrubber monitoring system, capital cost was estimated at \$24,300 and annual cost at \$5,600/yr.

- For an SNCR monitoring system, capital cost was estimated at \$10,300 and annual cost at \$3,200/yr.

For default parameters and equations used for monitoring costs, see Table 6b. Sources for specific cost data are noted below the table.

a. Testing Costs.

1. *Initial Stack Testing.* It was assumed that initial stack testing will be required for each pollutant that the ICR testing showed did not meet the proposed emission limit. Any unit having no test data for certain pollutants will also be required to perform an initial emissions test for those pollutants. Table 6c presents a summary of required initial stack testing for each unit. Costs for each required stack test were summed and multiplied by 2/3 to adjust for economies of scale when multiple pollutant tests were being performed on a unit. The annualized costs were calculated assuming a capital recovery factor of 0.10979 (15 years at 7 percent). The basis of these cost estimates for each stack test is summarized in Table 6d.

2. *Annual Stack Testing.* It was assumed that all units, to some extent, will be required to demonstrate ongoing compliance with the emissions limits for all pollutants. It was assumed that all units will be required to conduct annual stack tests for pollutants if they could not demonstrate the following:

Metals (Cd, Pb, Hg), PM, CO, HCl, NO_x, SO₂, PCCD/PCDF: performance at or below 75 percent of the MACT standards

Dioxins/Furans: performance at or below 50 percent of the MACT standards

It was assumed that units meeting these criteria would need to test only once every three years. Using baseline concentrations (the determination of which is described in the revised baseline emissions memorandum²), annual testing costs were estimated by dividing individual pollutant test costs by 3 where these criteria were met. Unit by unit costs are listed in Table 6d. The resulting annual average cost for this testing for each unit was estimated to be approximately \$22,000/yr.

3. *Visible emissions testing.* All SSI units will likely have ash handling operations. Therefore, these units would be required to demonstrate compliance to a 5 percent visible emissions limit for fugitive emissions generated during ash handling (similar to HMIWI). We are proposing that units will be required to conduct annual performance tests for fugitive emissions from ash handling using EPA Method 22. Costs for this annual test include a capital cost of \$250 and an annual cost of \$200, based on the *Revised Compliance Costs and Economic Inputs for Existing HMIWI* memo.⁸ Further details regarding this cost estimate are included in Table 6e.

b. Recordkeeping and Reporting Costs

For all units, a flat rate of \$2,989 per year was estimated as the annual cost for recordkeeping and reporting. Further details regarding this cost estimate, including hourly labor assumptions, labor rates, and associated sources, are included in Table 6f.

3.3 Alternative Disposal Costs

Certain SSI units may have waste disposal alternatives other than combustion available to them, and these alternatives may prove to be less costly than the controls and monitoring required for compliance with the proposed SSI standards. To determine if landfilling would be an affordable option for facilities even in the absence of the proposed standards, both the annual cost to landfill and the annual unit operating cost were estimated. Then, the overall cost for the landfilling option was calculated using the following equation:

$$\text{Annual Cost for Landfilling Option} = \text{Annual Cost to Landfill} - \text{Annual Cost to Operate SSI Unit}$$

Unit-specific operational costs, landfilling cost, and total annual costs for the landfilling option are listed in Tables 2a and 2b. The methodology for determining annual landfilling costs and annual unit operational costs is described below.

a. Cost to Haul to Landfill

The cost to haul waste to a landfill is the sum of additional sludge storage costs, landfill tipping fees, and transportation costs, which depend on the amount of waste to be hauled and the distance traveled per haul.

If choosing to landfill, it was assumed that a facility would need adequate storage capacity to store a minimum of 2 to 4 days worth sludge, to account for occasional multi-day landfill closures (e.g. weekends and holidays). Based on feedback from commenters, an average capital cost of \$30 million was assumed for a facility to construct a sewage sludge storage unit with odor control and a truck-loading facility for the sludge. Costs were annualized based on a 7 percent interest rate and a 30-year lifetime, this yields an annual cost of \$2.4 million for the storage facility.

Tipping fees used in the analysis were specific to each state where state data were available⁹; where state data were not available, landfill tipping fees were based on regional tipping fees.¹⁰ Additional tipping fees provided by commenters on the proposed rules were inserted where applicable. All fees were in units of \$/ton waste and were converted to 2008 dollars. The annual tonnage of waste being diverted was calculated based on the wet sludge feed rate of each unit and the number of hours it operates per year. Operational hours and sludge feed rates are discussed in further detail in the SSI inventory, baseline emissions, and database corrections memos.

Transportation costs were based on an estimated \$0.266 per ton-mile¹¹. It was assumed that a landfill could be found within 50 miles of each facility, yielding a roundtrip distance of 100 miles. However, a review of state regulations for states where small entities are located revealed that Connecticut and New Jersey do not allow sewage sludge to be landfilled. To adjust for this, round trip distances for facilities in these states were increased to 200 miles, assuming a landfill could be found in another state within 100 miles from the facility. Additionally, distance

information provided by commenters to the proposed rules were incorporated as appropriate into the cost calculations.

Annual landfilling costs varied widely, ranging from \$899,000/yr to \$17.1 million/yr. Table 7a summarizes the parameters and equations used to calculate the annual cost for each facility to landfill the waste it would otherwise incinerate in an SSI.

b. Cost to Operate Incinerator

Annual incinerator operational costs were based on data provided from the ICR survey and known unit capacities. The survey specifically requested that respondents provide annual costs to operate each incinerator in 2006, 2007 and 2008. Costs were then confirmed or revised based on follow-up contact with the survey recipients. Several steps were taken and assumptions made to standardize the data: (1) total costs provided were assumed to be for operating *only* the incinerator (i.e. did not include dewatering or other aspects of plant operation); (2) total costs listed for multiple units were divided evenly among each unit; and (3) individual cost components (e.g. electricity, labor, fuel) were summed if a total cost was not explicitly provided.

Because cost information was only available for the 9 surveyed entities, an annual cost factor, in \$/dry ton, was developed using the available data and multiplied by the average capacities of all other units. Both an average factor (\$179.22/dry ton for FB units and \$368.45/dry ton for MH units) and a minimum factor (\$62.52/dry ton for FB units and \$87.91/dry ton for MH units) were calculated and applied. The minimum factor is the most conservative estimate (i.e. would yield the lowest unit operational cost and thus the highest net cost for the landfilling option) and was used for the economic analysis.

Table 7b summarizes the information provided, assumptions made, and cost factors used to estimate costs for all units not having cost data.

4.0 EMISSION REDUCTIONS

Emissions reductions were calculated for each of the nine pollutants for two cases: (1) using flow rates calculated from actual sludge usage data; and (2) using flow rates calculated from sludge capacity. The derivation of these two sets of flow rates is discussed in further detail in the database revisions memo.⁵ Emission reductions were calculated by estimating the emissions resulting from each scenario and subtracting the baseline emissions previously calculated. The baseline memorandum indicates that emissions and flow rate information was collected from only 26 of the 204 SSI units. As described in the baseline memorandum, default factors for emissions, flow rate, and sludge capacity were developed and applied to units without data. Because the cost to landfill is prohibitively high for most entities, it was assumed all entities would choose to comply with the final rules rather than landfilling, and emission reductions were not calculated for the alternative disposal scenario described in Section 3.3, above.

4.1 'Actual' Emission Reductions (based on average feed rates)

Table 8a presents the total expected emissions reductions by subcategory based on flow rates derived from actual reported feed rates (see database revisions memorandum⁵ for more information). Details by unit are provided in Tables 9a-9c. Emission reductions were calculated using the following equation:

$$\text{Reduction} = \text{Baseline} - \text{MACT Floor Emission}$$

The calculation of baseline emissions are described in detail in a separate memo.² The MACT floor emission values, resulting from all entities meeting the proposed limits, were calculated as follows:

a. Units already meeting the proposed limits.

If a unit was already meeting the MACT floor for a given pollutant, then the MACT floor emission value was assumed to equal the baseline value (i.e., no backsliding or emissions increases would occur), yielding zero reduction.

b. Units not currently meeting the proposed limits.

For units not already meeting the MACT floor for a given pollutant, it was assumed that with the proposed limits in place the unit would reduce its pollutant concentration to at least that of the floor. Thus, the reduction would be the difference between the baseline and the proposed limit.

4.2 'Potential' Emission Reductions (based on maximum feed rates)

'Potential' emission reductions were calculated in the same way as 'actual' reductions, except that flow rates calculated from sludge capacities were used, rather than actual sludge usage, in calculating the baseline and MACT floor emissions. Table 8b presents the total expected emissions reductions by subcategory based on flow rates derived from unit design capacities (see baseline emissions memo for more information). Details by unit are provided in Tables 10a-10c.

5.0 REFERENCES

1. “Revised MACT Floor Analysis for the Sewage Sludge Incinerator Source Category” Memorandum from Eastern Research Group, Inc. to Amy Hambrick, U.S. Environmental Protection Agency. 2011.
2. “Revised Analysis of Beyond the Maximum Achievable Control Technology (MACT) Floor Controls for Existing SSI Units” Memorandum from Eastern Research Group, Inc. to Amy Hambrick, U.S. Environmental Protection Agency. 2011.
3. “Revised Estimation of Baseline Emissions From Existing Sewage Sludge Incineration Units” Memorandum from Eastern Research Group, Inc. to Amy Hambrick, U.S. Environmental Protection Agency. 2011.
4. “Development of the Inventory Database for the Sewage Sludge Incinerator Source Category” Memorandum from Roy Oommen, Eastern Research Group, Inc. to Amy Hambrick, U.S. Environmental Protection Agency. June, 2010.
5. Post-Proposal SSI Database Revisions and Data Gap Filling Methodology. Memorandum from Eastern Research Group, Inc. to Amy Hambrick, U.S. Environmental Protection Agency. January 2011.
6. U.S. Environmental Protection Agency. *OAQPS Control Cost Manual*. Publication Number EPA/452/B-02-001.
7. U.S. Environmental Protection Agency. July 1994. *Medical Waste Incinerators-- Background Information for Proposed Standards and Guidelines: Model Plant Description and Cost Report for New and Existing Facilities*. Publication Number EPA-453/R-94-045a. (Docket item no. II-A-112)
8. Memorandum from Thomas Holloway, RTI, to Ketan Patel, EPA. July 6, 2009. *Revised Compliance Costs and Economic Inputs for Existing HMIWI*.
9. *The State of Garbage in America, Table 4*. BioCycle December 2008, Vol. 49, No. 12, p. 22.
10. *NSWMA’s 2005 Tip Fee Survey, Table 1*. Edward W. Repa, Ph.D. NSWMA Research Bulletin, March 2005.
11. Hauling cost: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics. Table 3-17: Average Freight Revenue Per Ton-mile.

6.0 TABLES

The tables referenced throughout the body of this memo are presented in separate MS Excel files. They are organized as follows:

1. Percent Improvement Required to Meet MACT Floor:
CostandReductionsMemo_Table1.xlsx
 - 1a: Fluidized Bed Units
 - 1b: Multiple Hearth Units
2. MACT Floor Costs and Alternative Disposal Costs by Unit:
CostandReductionsMemo_Table2.xlsx
 - 2a: Fluidized Bed Units
 - 2b: Multiple Hearth Units
3. Summary of MACT Compliance and Alternative Disposal Costs:
CostandReductionsMemo_Table3.xlsx
4. Control Cost Algorithms:
CostandReductionsMemo_Table4.xlsx
 - 4a: Venturi Scrubber Algorithm Output
 - 4b: Venturi Scrubber Defaults
 - 4c: Packed-Bed Scrubber
 - 4d: Selective Non-Catalytic Reduction (SNCR)
 - 4e: Wet Electrostatic Precipitator (WESP)
5. Input Parameters for Control Cost Algorithms:
CostandReductionsMemo_Table5.xlsx
 - 5a: Fluidized Bed Units
 - 5b: Multiple Hearth Units
6. Stack Testing, Monitoring, and Recordkeeping Costs:
CostandReductionsMemo_Table6.xlsx
 - 6a: Maintenance and Inspection
 - 6b: Monitoring
 - 6c: Initial Stack Testing Costs by Unit and Pollutant
 - 6d: Stack Testing Costs
 - 6e: Visible Emissions Testing
 - 6f: Recordkeeping and Reporting

7. Alternative Disposal Cost Option:
CostandReductionsMemo_Table7.xlsx
 - 7a: Landfill Cost Algorithm
 - 7b: Reported SSI Operating Costs and Cost Factors
8. MACT Floor Emission Reductions Summary:
CostandReductionsMemo_Table8.xlsx
 - 8a: 'Actual' Emission Reductions
 - 8b: 'Potential' Emission Reductions
9. Emission Reductions by Unit: 'Actual' Reductions:
CostandReductionsMemo_Table9.xlsx
 - 9a: Emission Reductions
 - 9b: Baseline Emissions
 - 9c: MACT Floor Emissions
10. Emission Reductions by Unit: 'Potential' Reductions:
CostandReductionsMemo_Table10.xlsx
 - 10a: Emission Reductions
 - 10b: Baseline Emissions
 - 10c: MACT Floor Emissions